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REMARKS

ON THE

COUNTRY AROUND THE WREKIN:

A COMPARISON

OF THE

CARBONIFEROUS ROCKS

OF

COALBROOK DALE,

WITH THOSE OF OTHER DISTRICTS,

BY

CHARLES RICKETTS, M.D., F.G.S.

Reprinted from the Proceedings of the Liverpool Geological Society, 1875-76.

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REMARKS ON THE COUNTRY AROUND THE WREKIN.

By Charles Ricketts, M.D., F.G.S.

Read before the Liverpool Geological Society, December 14th, 1875.

In directing attention to the country around the Wrekin, it is not intended to give a detailed account of the Geology of a district already so well known, nor am I aware that I shall be enabled to bring forward any new facts; my desire is rather to place phenomena observed there in a different light, and, comparing them with those of other districts, to use them for the illustration of principles—some not as yet generally accepted—which I have had occasion to bring before the notice of the Society on various occasions.

The Wrekin, which rises a conspicuous object above the surrounding country to the height of 1320 feet, consists of a volcanic mass which has, in its passage through a rent formed in the Caradoc rocks, converted the sandstone strata into quartzite. It extends in a direction from N.E. to S.W. for about three miles; being, independently of the hardened quartz rock flanking its sides, a quarter of a mile wide at its greatest breadth, but becoming narrower at other places to less than an eighth of a mile. The character of the rock varies, being hard and compact where a little stream has cut for itself a channel dividing the hill into two parts, and through which the road to Wellington passes; whilst at its northern extremity, at Ercal Wood, it forms large rounded masses of a red colour, which, by weathering, separate in concentric coats, these again breaking into small pieces make a good substitute for gravel, in place of which it is extensively used.*

* "A similar rock forms the nucleus of Primrose Hill, at the south-western extremity of the range."—"Notes on the Geology of North Shropshire," by Charlotte Eyton, p. 18.

If the direction of the longer axis of the Wrekin is extended for about nine miles, the line will pass very nearly into the eruptive rocks of the Lawley and Caradoc Hills. This "long line of dislocation and faults extends for 65 miles, from Coalbrook Dale, S.W., to the neighbourhood of Gladestry, in Radnorshire."* So that, as modern volcanos occur along definite lines, their "great trains of vents, indicating the existence of extended fissures or lines of dislocation across the earth's crust, through which subterranean igneous matter has for a vast series of ages been habitually protruded," † it may be presumed that these ancient ones have been situated along similar lines of weakness; but, as now, so also then, the fissures along which the vents have occurred did not permit the molten rock to pass entirely through the earth's crust, from the interior to the surface, along its whole length, otherwise a dyke would have extended the whole distance between the different foci of eruption.

There is no evidence remaining to indicate the period when the volcanos near Church Stretton—the Lawley, the Caradoc, and Cardington Hills—were in a state of activity; every trace of the accumulation of ashes and lava which once issued from these volcanic vents has been removed by denudation, which occurred previous to the subsequent deposition of any stratified rock now remaining. With respect to the Wrekin, it is different. Extending parallel to it for nearly its whole length, but separated by a space of from half a mile to a mile, there are displayed on its eastern side the remains of a succession of bands of basalt and volcanic ash; the latter, by the innumerable volcanic bombs with which it is studded, seen along the road as it approaches Little

* Professor Ramsay.—"Horizontal Sections of the Geological Survey," sheet 54; Explanation, p. 1.

† "Volcanos," p. 258.—G. Poulett Scrope, F.R.S.

Wenlock, indicates the near vicinity of the crater from which they had been ejected; and the irregular and unstratified manner in which they lie embedded, with no stratified deposits intervening between the beds, proves that the eruption had been subaërial. The bombs are extremely like, both in size and appearance, many of those ejected during the progress of making steel by the Bessemer process. At Harris' Coppice is another ash-bed, apparently near to if not forming the base of the eruptive rocks, containing an abundance of small grains and lapilli; it has a bed of basalt resting upon it, both being overlaid by Millstone Grit.

These eruptive rocks lie successively on the eroded surfaces of the Caradoc and of the basement beds of the Upper Silurian strata, that is, upon the May Hill Sandstone and Conglomerate, and the Wenlock Shale; so that not only did the eruption take place after the deposition of the Old Red Sandstone, and the exertion of that power which has resulted in the tilting up, at a considerable angle, of it and the underlying strata, but also subsequent to the denudation by which even then the whole series, from the summit to the base, were displayed in this neighbourhood within an area of five or six miles. It is, in fact, to causes which were in action prior to the deposit of the Carboniferous strata, that the more prominent features in the present contour of this district are chiefly due.

Though the displacement and upheaval of the older stratified rocks occurred previous to the intrusion of what is now the Wrekin, the presence of this hard and unyielding mass appears, upon the occurrence of subsequent changes, to have had influence in determining the foldings which exist in the Carboniferous rocks of Coalbrook Dale, causing them to take place in a direction parallel to that of its longest axis.

Resting upon the lava and ashbeds is a bed of limestone, quarries of which have been opened in different places along the outcrop, extending from Little Wenlock in a northerly direction for about two miles; the occurrence in great abundance of *Productæ*, characteristic corals, and other fossils, refer it to the Carboniferous Limestone series. At its southern extremity, in Oldfield Quarry near Little Wenlock, the strata lie horizontally; but at Hatch they dip to E.S.E. at 22°, and at a higher angle further north. The limestone proper is, at the southern portion of the area, only 20 to 25 feet thick; and at Steeraway, further north, the vertical section of the Geological Survey makes it 40 feet; so that, compared with other districts, the thickness of this limestone is remarkably small. With the exception of a small area at the northern extremity of the Coalbrook Dale coal-field, and at the Titterstone Clee Hills (to be referred to hereafter), the nearest place at which the Carboniferous Limestone exists is Llanymynech, 30 miles distant to the north-west; Mr. G. H. Morton, F.G.S., calculates that its thickness there is about 400 feet, and has informed us that nine miles further north it gradually dwindles down to about 100 feet.* It again increases to 1,000, and even to 1,500 feet, in Denbighshire.† At Llanymynech it must have been deposited in a hollow formed in the older rocks—I should consider it to have been in a submerged valley—situated between the Breidden Hills and the extension of the Longmynd northwards on the one side, and the hilly country north of Llanfyllin on the other. A subsidence of all this land has taken place gradually and progressed simultane-

* Proceedings of the Liverpool Geological Society, 1875-76.

† "The Coal-fields of Great Britain."—Professor E. Hull. Second Edition, p. 99.

ously with the deposition of the limestone strata; the area about Llanymynech having been submerged, as is shown by the greater comparative thickness of its limestone, ages before that of its own extension northwards, or before the area of Little Wenlock reached the sea level; whilst the higher hills must have formed promontories, and some perhaps small islands, situated in a Carboniferous sea.

The limestone passes upwards into beds of sandstone and carbonaceous shale, having together about the same thickness as it. This estuarian deposit consists of materials such as might have been derived from the disintegration of the older rocks of the neighbourhood, and is referred to the Carboniferous Limestone series. Though at Oldfield Quarry these deposits are from 40 to 50 feet thick, there is nothing to represent them at Harris' Coppice, at a mile distance to the south on the Little Wenlock road, unless it be a band of muddy sediment not more than an inch in thickness; beds of conglomerate (Millstone Grit) lying immediately on the basalt and ash-beds. Bosses of igneous rock rise through the Millstone Grit at various places, whilst "others have been discovered in the deep workings."* So that the intrusive and erupted volcanic rocks, which had even then suffered much denudation, will have appeared above the level of these sedimentary deposits; and, if not forming islets during the deposition of the Carboniferous Limestone, they would at a later period, when the land was further depressed, during that of the Millstone Grit, in a manner similar to the small islands formed of volcanic rock situated in the Firth of Forth.

* "Geology of Coalbrook Dale," by Joseph (now Professor) Prestwich.—*Proc. Geol. Soc.*, vol. ii, p. 403.

The transition is sudden from the strata which have been referred to the Limestone Series to that of the Millstone Grit, the basement beds of which are conglomerates composed of rounded quartz pebbles. At one place the shales upon which they rest had rootlets passing from its upper surface perpendicularly downwards *in situ* as they had grown; so that this then surface of low-lying land must have subsided below the sea level, possibly was also partially denuded, thus permitting the deposition of materials which had been derived from a different and distant source. I traced the Millstone Grit of this district to its farthest extent southwards at Barrow, a farm two miles due east of Much Wenlock, where it overlies respectively the Upper Ludlow Shales, and the Old Red Sandstone; whilst near the Wrekin, at Harris' Coppice, where the Carboniferous Limestone does not exist, it rests upon the erupted matter which has issued from the volcano of the Wrekin.

These grits and conglomerates are eighty feet thick at Steeraway and form the base upon which the measures of the Coalbrook Dale Coalfield rest. Their margin indicates the extreme limits of a bay which the Carboniferous Sea occupied; the Longmynd, the Stiper Stones, and the Breidden Hills constituted a promontory separating it from the Oswestry district, where the Millstone Grit is, according to Mr. Morton, about 560 feet thick; whilst Wenlock Edge and its overlying Ludlow rocks and Old Red Sandstone formed an isthmus, dividing it from the bay in which was deposited the Limestone and Millstone Grit of the Titterstone Clee Hill. But in South Staffordshire the Coal-measures rest directly on Upper Silurian strata, so denuded that they overlie the whole series from the base of them, or May Hill Sandstone, near Barr, to the Aymestry Limestone at Sedgley; it therefore

seems certain that this land extended to the eastward by Dudley and Walsall, through Warwickshire to Leicestershire, and, though depressed to, or even below, the sea level, was never submerged during the Carboniferous period.*

The Clee Hills, situated on the southern side of this ancient isthmus, consist of several detached patches of Carboniferous rocks, resting upon Old Red Sandstone, which have been preserved from destruction by cappings of basalt. The more northern of these areas consist of Coal-measure strata only, whilst the Titterstone Clee Hill is composed also of marine beds of the Carboniferous series—Carboniferous Limestone and Millstone Grit. The Limestone differs most materially from any found further north, being characterized by an oolitic structure which, in a quarry to the north-east of Knowl, extended through its whole thickness, 25 feet; the shells contained in it having been broken into such small fragments that it was impossible to identify any. This oolitic character, common also in the Bristol area, indicates a great difference in physical conditions during the deposition, between what was here a submerged area forming a shallow bay and the sunken hilly districts farther north.† The Limestone of the Titterstone Clee Hill, was overlaid by about 60 feet of Carbonaceous Shale prior to the deposition of the Millstone Grit.

* The fact of this ridge existing during the Carboniferous period as a division between two seas, was demonstrated by the late Professor Jukes in "Memoirs of the Geological Survey—South Staffordshire Coalfield," preface, page xiii; and by his successor in the Geological Survey of Ireland, Professor E. Hull, in "The Coal-fields of Great Britain," page 108, and in *British Association Reports*, 1870, page 75, where he also shewed that the northern boundary of the Coal formation to the north of this central barrier was formed by the Cambro-Silurian rocks of the Lake-district and portions of the "southern uplands" of Scotland.

† Mr. Morton informs me that some of the beds of limestone in the Llanymynech district are oolitic in structure.

The land which, at the commencement of the formation of the Coal-measures, was, near Coalbrook Dale, the boundary of the Carboniferous sea, rose from its shores to a considerable elevation above its level, as at Benthal Edge, Wenlock Edge, the Longmynd, and towards the Breidden Hills; a marine plain formed of the conglomerates and sandstones of the Millstone Grit being the base upon which they were deposited. During the earlier period of their formation the accumulation was neither very great, nor the subsidence considerable, when compared with other coalfields, the partings between the lower or workable beds of Coal being thin, and the deposit chiefly consisting of a fine ferruginous clay. Taking the section at Lawley as given by the Geological Survey* (and it very nearly coincides with other sections, and with information derived from workmen) the strata in which the profitable Coals lie, from the Top Coal to the Little Flint Coal, is 180 feet thick, containing thirteen beds of Coal amounting to 40 feet in thickness, and the measures to 140 feet, being a marked contrast when compared with those of other districts. Professor Hull states that in Denbighshire the Middle Coal-measures, which are the only ones worked, have in a thickness of 800 feet of strata an aggregate amount of from 27 to 30 feet of workable Coal, the lower measures, about 1000 feet thick, having several seams varying from 2 to 3 feet, but are little sought after in the presence of the thick seams of the middle series.† Professor Hull states that in the St. Helens district the strata from the Lyons Delf to the Arley Main Coal is 1807 feet, with an aggregate of 59 feet 6 inches of Coal,‡ and observes that

* Vertical Sections, Sheet No. 32.

† *The Coalfields of Great Britain.*—By Professor Edward Hull, Second Edition, pages 99 and 100. ‡ Page 124.

"there is a general thickening of the sedimentary materials, as sandstones and shales, to the N.N.W. Thus the same coal-seams are farther apart at St. Helens than at Prescot, and at Wigan than at St. Helens."* The Lower Coal-measures or Gannister beds are 1800 feet with 6 or 7 seams of coal, seldom of greater thickness than 2 feet for each.†

Professor Jukes has conclusively proved that the *Thick or Ten-yard Coal* of South Staffordshire, which, in the neighbourhood of Dudley, consists of thirty feet of coal without any or with but very thin partings, is, five miles to the north of Bilston—at Essington and Wyerley—represented by ten beds of coal and interposed shales and sandstones, amounting together to the thickness of 300 feet. The aggregate thickness of the coal is the same, the increase being entirely due to the amount of sedimentary materials between the beds.‡ It may, I consider, be inferred that at the southern portion of the district, near the summit of the ridge previously referred to, the land, during the period of the growth of the enormous amount of vegetation forming the "thick coal," continued persistently stationary; whilst towards the north, that is, somewhat nearer the source of the sedimentary deposits, there was a gradual and progressive subsidence, which proceeded in a greatly increased ratio further northwards.

Where the Measures in Coalbrook Dale are situated above the Millstone Grit, they contain many valuable beds of coal, whilst those formed later and upon old land surfaces, extending southward to the Forest of Wyre and from Caer Caradoc by Shrewsbury to Alberbury, are of a comparatively "valueless nature," containing at the most

* Page 123. † Page 127.

‡ "Memoirs of the Geological Survey—South Staffordshire Coal-field."

only "two or three coal-seams not of sufficient value to induce mining operations far from the outcrop." "The strata belong generally to the higher part of the coal series which throughout England is but sparingly enriched with beds of coal."* The contrast between the different coal-fields is remarkable; the one studded all over with numerous shafts, the other with but here and there evidence that coal has been "gotten," and that generally consisting only in the bank of a deserted colliery.

It has been shown that, prior to the eruption of a subaërial volcano (whose vent is now represented by a portion of the igneous rock which constitutes the Wrekin), the Old Red Sandstone, the Upper Silurian and the Caradoc strata had been upheaved and extensively denuded; and that remains of the materials ejected are distributed on the eroded surfaces of the two older formations. The northern extremity of Wenlock Edge and of the Longmynd constituted higher ground encircling this area, which by depression formed a bay; these same hills became an isthmus separating it from another bay situated a few miles southward, its most northerly extension being the Titterstone Clee Hill. The erupted rocks had undergone a considerable amount of denudation previous to their depression beneath the sea. That this subsidence was gradual, and occurred towards the termination of the period of the formation of the Carboniferous Limestone, is indicated by its being much greater in thickness at Llanymynech, and especially farther north, compared with its small amount here, where it is at the utmost eighty feet, and thins out entirely within a very short distance.

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* *Idem*, pp. 91–92.

There are in various other places indications of the Carboniferous Limestone having been deposited in areas which had previously been more ancient valleys, as in Anglesey, near Denbigh and Llangollen, and in Cumberland, where the base of the Carboniferous series is not unfrequently represented by what has been erroneously designated Old Red Sandstone, now recognised by the staff of Her Majesty's Geological Survey as "Carboniferous Basement Beds;" "they contain fragments derived entirely from rocks which are seen in the immediate neighbourhood,"* and the limestone lies conformably upon them; whilst, in the different districts, it may be seen within a short distance resting on the eroded surfaces or edges of older rocks. It is more than probable that these conglomerates and sandstones are situated in the bottoms of ancient valleys, and were deposited near the mouths of their rivers. As depression progressed these strata were overwhelmed by the sea; and the valleys, changed into estuaries and bays, permitted the limestone to be deposited on their flanks, filling them up entirely, and this continued until the ridges even were deeply buried beneath it.

The origin of any extraneous materials the Carboniferous Limestone contains may also with probability be referred to the disintegration of land in the neighbourhood; but its large area and great thickness indicate the prolonged degradation of some large continental area

*Mr. (now Professor) T. McK. Hughes, when referring to these strata in Westmoreland and Cumberland.—*Memoirs of the Geological Survey—Kirkby-Lonsdale*, p. 15. Mr. J. Goodchild, of H.M. Geological Survey, also says that in the valley of the Eden this basement series "seems to be mainly composed of locally derived materials."—*Quart. Journ. Geol. Soc.*, vol. xxx, p. 396. Mr. Tiddeman has remarked that the Mountain Limestone is 3,000 or 4,000 feet thick in the Lake district, and in the Pennine chain, at a distance of 15 miles, only 600 feet.—*Quart. Journ. Geol. Soc.*, vol. xxx, p. 400.

during the period of deposition.* The *débris* must have been carried by its river as sediments into the sea at some locality unknown to us; whilst the lime, held in solution by its waters, was at the same time conveyed and distributed by currents, being utilised where found by corals, mollusks, and other organisms, or was otherwise deposited.

The effects produced were immense, though the physical changes which induced them may have been small, by which the great submarine plateau of Carboniferous Limestone became the basis on which were distributed materials as different from it as are those which constitute the Millstone Grit (including also, under that term, the Yoredale series of rocks), and those which were subsequently deposited—the delta-formed strata of the English Coal-fields. The abundance of mica and of quartz in these deposits, refers their origin to the disintegration of granitic or gneissic rocks, probably of an extensive mountain range; whilst the Coal-measures must be compared to the delta of some large river, on whose alluvial plains grew the abundant vegetation now represented by the various beds of coal; the clays, shales, and sandstones being mud and sand which overspread these plains when the river overflowed or broke through its banks.

The circumstance of the general and persistent depression of the bed of the sea as the accumulation of limestone progressed, and the fact that, in the neighbourhood to which especial attention is being directed, there was an isthmus sixteen miles wide, forming a division between two seas,† may afford a clue to determine the

* "In the open sea, at a distance from any land, lime is said to be rarely, if ever, discoverable by analysis."—Jukes' "Student's Manual of Geology," 1862, p. 125.

† It was reduced to twelve miles during the deposition of the Millstone Grit.

circumstances under which these changes have taken place. The abundance of the lime must have required the existence of a large river flowing through a limestone district, emptying itself into the sea, probably within at the utmost a few hundred miles of the place where the limestone has been deposited. This proximity is not an absolute necessity, for the lime in the *globigerina* ooze of the mid-Atlantic has its source in the great rivers of America. A large river was needed to convey the sand, mica, and mud of the Coal-measures from the gneissic and granitic mountains from whose disintegration they have been chiefly derived, and which, as the river overflowed or broke through its banks, and as subsidence of the land progressed, overwhelmed the alluvial plain with waters holding in suspension all but the coarser sediments. A large river would also be required as a means by which the materials derived from the same—at all events, a similar origin—forming the Millstone Grit, might have been brought within the influence of the action of the sea. Many of its particles are much coarser than any found in the Coal-measures; its sands and grits are to a great extent more or less angular, and must have been carried along by the rapidity of the stream without much friction; whilst the larger fragments of quartz are invariably rounded, probably as a result of exposure to constant friction by being pushed along the river-bed. They were subsequently distributed by tidal and other currents over the bed of the sea; filling up the space between the upper surface of the Carboniferous Limestone almost to the surface level of the sea, and, though there was a considerable amount of subsidence continually taking place whilst this accumulation was progressing, they sometimes, as in Yorkshire, formed low-lying land, which remained

above the sea-level sufficiently long to admit of the growth of vegetation to produce beds of coal. The beds of coal interstratified with the Yoredale shales and Millstone Grit of Penygent may be cited as examples. This *débris* would also have been carried into bays, like that at Coalbrook Dale, where they would have been distributed in a similar manner to the sands in Morecambe Bay, derived chiefly from the degradation of the Triassic rocks of Lancashire and Cheshire, forming a plain at a level between high and low water mark.

A difficulty arises in determining the causes by which the barrier was removed between the Carboniferous sea of the north-west of England and the great river, whose existence I think is certain, but its course unknown. An isthmus, as has been shown, divided this great northern bay from another situated further south, the elevation of the ridge between them being so small that, had subsidence progressed there during the period of the marine deposits of the Carboniferous formation, to an extent moderate compared with what occurred in other places, a junction or strait must have been formed between the two seas. Let us suppose a circumstance somewhat similar, and not unlikely to have happened. That the marine area, in which the Carboniferous Limestone was being deposited, was separated by a ridge or range of hills from the valley through which the supposed large river flowed; the limestone area we know was persistently subsiding; and, if there was much sediment brought down by the river, judging from what is observed in so many great rivers, subsidence would take place and a delta be formed at its embouchure.* This depres-

* The St. Lawrence, in consequence of the detritus being detained in numerous extensive lakes, *may* be an exception.

sion would continue as the accumulation progressed, so that the valley would be entirely filled with the deposit forming the delta and alluvial plain; and the bed of the river might also become somewhat higher than some lower portion of the ridge. The tendency would then be for a channel to be formed communicating with the bay, which, uniting with the main stream, would, according to its size, divert into it a large portion of materials such as had previously passed into an adjoining sea.

Though there is no known deposit during the Carboniferous period which can be referred to delta-accumulations, such as have been supposed, the suggestion may be made whether the Calciferous Sandstone series in the neighbourhood of Edinburgh may not represent sediments which have filled up the valley formed by a large tributary of such a river. These strata amount altogether to a thickness of 3,500 feet; and they, as well as the Carboniferous Limestone and Millstone Grit, have been formed under conditions differing in a most marked manner from those deposits in England which have been under consideration and are referred to the same periods.

The diversion of a continental river into such an area as that occupied by the Carboniferous Limestone, however it may have originated, would have brought into it the *débris* derived from the degradation of the land, which would have been distributed over the bed of the sea by tidal and other currents. As deposition went on, depression of its bed would have progressed, not always continuously in any single locality; for sometimes, as in the Yoredale series and Millstone Grit of Yorkshire, it became filled up to the surface level of the sea, and land surfaces were formed, on which vegetation flourished, so as to form beds of coal; such surfaces subsequently

became depressed and covered with other beds of micaceous shales, sandstones, and grits; and this process was repeated many times in succession. In some districts the total thickness of these sediments amounts to 5,000 feet; whereas at the extreme limit of the bay at Coalbrook Dale, where they overlie the Limestone, but were in the immediate neighbourhood of land, they are represented by 80 or 100 feet only; thinning out entirely at Barrow Farm. This slight subsidence may be due to the accession of pressure from accumulation occurring from one direction only, whereas at so short a distance as thirty miles, at Llanymynech, where a greater thickness of Limestone indicates the existence of a more expansive sea, the accumulation amounts to 560 feet.

The *débris* brought down into this sea overspread and filled up the whole area until, subsidence ceasing to progress in equal ratio with the deposition, no more was distributed from seaward, and the stream passed along a channel in this marine plain. In the subsequent deposits, forming the Coal-measures, there are sandstones and shales, with abundance of quartz and mica entering into their composition, similar in character to those in the Millstone Grit; they may therefore be referred to the same origin, but the grittier and coarser particles are wanting, and there is an entire absence of the rounded quartz pebbles. These pebbles must, with other materials, have still been propelled seaward; but portions, which consisted of such fine materials as were capable of being suspended in the current, were deposited upon the inundated plain when the river broke through or overflowed its banks.

By comparing the delta-deposits of the Coal-measures with those of large rivers, such as the Mississippi, it will be perceived that, though the bursting of the banks would

have overwhelmed the plain, covering it with sand and silt, it could not exceed the height of the banks, amounting in the Mississippi to a mean depth of fifteen feet.* There must, therefore, in order to permit the accumulation of the great thickness of strata which exists between the different beds of coal in the more northern districts, have been a successive depression of the land as accumulation progressed. Near the course of the river through the delta the greatest amount of accumulation would occur, becoming lessened and the sediment being finer, as the distance increased, whilst at its extreme limits there would remain only the finest particles of mud. This has been the case in the Coalbrook Dale district, situated in the depressed and filled up site of the commencement of one of the minor tributaries of a large valley or system of valleys, situated on the northern slope of the division of the watershed which separated it from a similar area to the south.

Whether or not this is the correct explanation of the formation of the Carboniferous rocks of the northwest of England, the fact is evident that subsidence of the land progressed simultaneously with the accumulation. Every seam of coal represents the surface of a plain or delta, situated but little above the sea-level, each representing the product of vegetable growth which had flourished for a prolonged period of time; every considerable accumulation between each bed indicates subsidence of the land. This depression is shown to have been in accordance with the amount of accumulation, occurring in some places to an enormous extent in each of the several divisions of the Carboniferous system; whilst in others, as in that of Coalbrook Dale, in each of them it has been small. Nor is the simultaneous occurrence of

* Sir Charles Lyell.

accumulation and subsidence by any means peculiar to the Carboniferous rocks, but can be proved to be coincident during all geological time—from the Laurentian rocks of Canada to the deltas now forming at the mouths of large rivers. Its occurrence is proved wherever in lower beds there are data to determine at the period of their deposition the near proximity to the horizon of the then sea-level or of shallow water, and the subsequent deposition of strata upon them.

Such a simultaneous occurrence of these phenomena during every age and through all time, can only be regarded as the result of cause and effect: that the one is dependent upon the other. Depression may *permit*, but cannot *cause* accumulation. In the instances which have been under consideration the materials have been derived, not from the neighbourhood, but from distant sources, whilst the accumulated weight of the sediments deposited in seas, bays, and deltas is, by the pressure exerted on the crust of the earth, an adequate cause for the occurrence of the depression; the amount of subsidence being greater or less, in accordance with that of the accumulation.

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